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PATENT

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Docket No: THEURER-21

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Washington, D.C. 20231

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ANTONELLA FUSILLO

(Name of person mailing paper or fee)

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(Signature)

SIR:

Transmitted herewith for filing pursuant to 37 C.F.R. §1.53(b) is the patent application of:

Inventor: JOSEF THEURER & BERNHARD LICHTBERGER
For: METHOD OF SURVEYING A TRACK

Enclosed are:

- (X) Specification with 14 pages, 2 claims and 1 sheets of drawing.
- (X) Declaration with (X) Power of attorney.
- () Small entity statement.
- (X) Assignment.
- (X) Cover letter in compliance with 37 C.F.R. §3.31 to accompany the assignment submitted for recording.
- (X) Check in the amount of \$730.00 for covering the filing fee of \$690.00 and the official fee of \$40.00 for recording the Assignment.
- (X) Self-addressed postcard.
- (X) A priority document.
- (X) Information Disclosure Statement with (X) PTO-Form 1449 and (X) copy of reference(s).

(X) The filing fee is calculated as follows:

Basic Fee:	\$690.00
Additional Fees:	
Total number of claims: 2-20	\$00.00
Number of independent claims: 2-3	\$00.00
Reduction by 50% for filing by a small entity	\$
TOTAL	\$690.00

(X) The Commissioner is hereby authorized to charge any fees which may be required, or credit any overpayment to Deposit Account No.: 06-0502. A duplicate copy of this sheet is enclosed.

Pursuant to the provisions of 37 C.F.R. §1.10 and §1.53, applicant respectfully requests that this application be assigned an application number and a filing date of February 10, 2000, the date upon which the application was mailed to the Patent and Trademark Office by Express Mail.

Applicant hereby claims priority under 35 U.S.C. §119 (a) - (d) on the basis of Austrian Patent Application No. A 204/99, filed February 12, 1999.

Respectfully submitted,

By: 

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1 JOSEF THEURER & BERNHARD LICHTBERGER, citizens of
2 Austria, whose residence and post office addresses are Johannesgasse 3,
3 A-1010 Vienna, Austria and Im Bäckerfeld 15, A-4060 Leonding, Austria,
4 respectively, have invented certain new and useful improvements in a

5
6
7
8 METHOD OF SURVEYING A TRACK
9
10
11

12 of which the following is a complete specification:
13

000720-19270560

METHOD OF SURVEYING A TRACK

BACKGROUND OF THE INVENTION

The present invention relates, in general, to track survey methods, and more specifically to a method of surveying a track, in which a first and a second measuring vehicle are positioned at end points, respectively, of a track section to be measured during a measuring cycle, the first measuring vehicle being designed for mobility independently of the second measuring vehicle which is stationary during the measuring operation, and the position coordinates of the second measuring vehicle are determined, a reference line in the form of an optical measuring beam is set up between the two measuring vehicles, and the mobile, first measuring vehicle is advanced in the direction towards the stationary, second measuring vehicle while any change in position of a receiving unit, mounted on the first measuring vehicle, relative to the reference line is registered as a correction measurement value.

A method of track surveying with a track pre-measurement car called EM-SAT is described in the publication "Der Eisenbahningenieur" ("The Railway Engineer"), May 1995, pages 314 to 318. The measurement operation is carried out in a cyclical fashion. The measuring vehicle (also called satellite) which is stationary during the surveying operation is first moved along the track in the operating direction until it is close to the next geodetically surveyed reference

1 point, normally located on a catenary mast. A laser beam emitter mounted on the
2 satellite is aligned with regard to said reference point, adjoining in the transverse
3 direction of the track, and thus is brought into an exact desired position.
4 Thereafter, with the aid of a telescope fastened to the laser beam emitter, the
5 latter is aligned with a receiver located on the main machine which constitutes
6 the other, mobile measuring vehicle. During this, the measuring axle of said
7 mobile measuring vehicle is stopped exactly at a reference point which has
8 previously been marked with paint at the rail base. This precise positioning is
9 facilitated by a video camera showing the rail base and the wheel of the
10 measuring axle.

11
12 The actual surveying of the track section is initiated by advancing the
13 mobile measuring vehicle, with the position of the laser beam relative to the
14 actual position of the track being measured at intervals of 20 centimeters and
15 stored. With the aid of a special computer program it is possible to calculate from
16 the geometrical data in a track monument plan the desired versines for line and
17 level. To do this, it is merely necessary to input the track geometry and the
18 position of the reference points. These versine values serve for comparison to
19 the measured versines, with the difference thereof producing the correction
20 values for level and line. The surveying of the track section is finished as soon as
21 the mobile measuring vehicle has reached the stationary measuring vehicle.
22 While the stationary measuring vehicle is advanced to the next reference point in
23 order to carry out the succeeding measuring operation, the displacement- and

1 lifting values for the just surveyed track section are computed. The determined
2 correction values may be stored on a floppy disk to be loaded into a tamping
3 machine, for instance, and to be worked off automatically for the accurate
4 correction of the track position.

5

6 U.S. Pat. No. 5,493,499 describes a method of surveying a track wherein
7 two measuring units, movable on the track, are placed at both end points of a
8 track section to be measured and their respective positions are defined in relation
9 to a track reference point. Subsequently, one of the two measuring units is
10 moved in steps in the direction towards the other measuring unit, wherein, at
11 every interruption of travel for implementing a measuring procedure, the
12 measurement data of the actual track position are compared with the
13 measurement data of the desired position and a corresponding differential value
14 is calculated and stored. In this, as a result of the reception of a position signal
15 from surveying satellites (Global Positioning System or GPS), the position of the
16 two measuring units relative to one another in a coordinate system is determined.
17 At each stop of the second measuring unit during its measurement travel in the
18 direction towards the opposite, first measuring unit, the respective relative
19 change in position is determined as a result of the reception of a further position
20 signal from surveying satellites.

21

22 Additional details regarding the said methods of track surveying are
23 described in the publication "Der Eisenbahningenieur" ("The Railway Engineer"),

1 August 1995, pages 560 to 563.

2

3 According to an article called "GPS-based data collection" in the
4 publication "Railway Age", December 1994, pages 66 and 67, it is known to use
5 GPS to determine which track sections require treatment.

6

7 Finally, a method and a device for rapidly and accurately determining the
8 position coordinates of a movable receiver relative to a fixedly installed receiver
9 are described in U.S. Pat. No. 4,812,991.

10

11 SUMMARY OF THE INVENTION

12

13 It is an object of the present invention to provide an improved method of
14 surveying a track, which enables a more rapid work progress while realizing a
15 very high precision of measurement.

16

17 This object, and others which will become apparent hereinafter, are
18 attained in accordance with the present invention by a method of surveying a
19 track which comprises the steps of positioning a first and a second measuring
20 vehicle at end points, respectively, of a track section to be measured during a
21 measuring cycle, the first measuring vehicle being designed for mobility
22 independently of the second measuring vehicle which is stationary during the
23 measuring operation, determining, at the start of each measuring cycle, position

1 coordinates of the stationary, second measuring vehicle, with the aid of a GPS
2 receiver mounted thereon, relative to a fixedly installed GPS reference station
3 located adjacent the track section to be measured, the coordinates of the GPS
4 reference station being known within a terrestrial coordinate system, setting up a
5 reference line in the form of an optical measuring beam between an emitter
6 mounted on the second measuring vehicle and a receiving unit mounted on the
7 first measuring vehicle, aligning the reference line with the first measuring vehicle
8 on the basis of the determined position data, advancing the mobile, first
9 measuring vehicle in the direction towards the stationary, second measuring
10 vehicle to carry out the track surveying operation, and registering as a correction
11 measurement value any change in position of the receiving unit mounted on the
12 first measuring vehicle relative to the reference line.

13

14 A measuring method of this kind has the particular advantage that the
15 laser beam emitter does not need to be aligned with respect to an adjacent
16 reference point in a time-consuming manner. Furthermore, the also time-
17 consuming task of positioning the two measuring vehicles precisely at the
18 beginning and end, respectively, of the track section to be measured likewise
19 becomes unnecessary in the process. Additionally, the track sections can be
20 surveyed overlappingly, avoiding a closed traverse. Finally, the surveyed position
21 data may also be used in an advantageous manner for creating a track position
22 plan with precisely defined, exact coordinates.

23

BRIEF DESCRIPTION OF THE DRAWING

The above and other objects, features and advantages of the present invention will be more readily apparent upon reading the following description of a preferred exemplified embodiment of the invention with reference to the accompanying drawing, in which:

FIG. 1 is a side elevational view of two measuring vehicles for surveying a track section in accordance with the present invention;

FIG. 2 is a schematic representation of a desired track position and a reference line formed by a laser beam between the two measuring vehicles; and

FIG. 3 to 5 are greatly simplified representations of different positions of the two measuring vehicles during track surveying operation.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

Throughout all the Figures, same or corresponding elements are generally indicated by same reference numerals.

Referring now to the drawing and in particular to FIG. 1, there is shown a

16 The stationary measuring vehicle 2 has a seat 17 for accommodating an
17 operator and is equipped with an emitter 18 in the shape of a diode laser
18 supported on the machine frame 6 for adjustment by means of drives (not
19 shown). A receiving unit 13 is arranged underneath the front end of the mobile
20 measuring vehicle 1, outside of the area defined by the two undercarriages 3.
21 The receiving unit 13 is designed as a high-speed image analyzing system for
22 localizing a reference line 14 which is formed by a laser beam created by the
23 emitter 18. The receiving unit 13 is articulated to one end of the machine frame 5

1 prior to the track surveying, taking into account the oppositely positioned
2 reference points 22, with the measuring results being written onto the ties, for
3 example. Although, the alignment of the emitter 18 could conceivably also carried
4 out by using a sighting telescope which is secured to the emitter 18; This
5 procedure is however time-consuming and requires precise positioning of the
6 mobile measuring vehicle 1 at the previously surveyed desired point 27.

7
8 In the following, the novel and inventive method for surveying a track
9 section 28 will be described in more detail with particular reference to FIGS. 3 to
10 5.

11
12 At the start of the track surveying operation, the stationary measuring
13 vehicle 2 is moved in the region of the track section 28 to be surveyed and
14 stopped as soon as the critical distance, subject to weather conditions, for
15 receiving the laser beam (reference line 14) has been reached. By activation of
16 the GPS receiver 19, position data of the stationary measuring vehicle 2 are
17 received and related to the known position data of a fixedly installed GPS
18 reference station 29 located near the track 9. Since the coordinates of the GPS
19 reference station 29 are accurately known within a terrestrial coordinate system,
20 the position coordinates of the stationary measuring vehicle 2 in the coordinate
21 system can also be accurately determined and transmitted by means of the radio
22 unit 20 to the controlling and computing unit 11. The controlling and computing
23 unit 11 instantly compares the position data with stored desired value data, and

1 considers a possible difference during the following surveying operation.

2

3 After the reference line 14 is set up by aligning the laser beam of the
4 emitter 18 with the receiving unit 13, the surveying operation of the track
5 section 28 is initiated by advancing the mobile measuring vehicle 1 in the
6 direction of arrow 12 toward the stationary measuring vehicle 2. During this
7 advance, the position of the reference line 14 relative to the actual track position
8 is measured at intervals of 20 centimeters, with the actual track position being
9 transmitted to the receiving unit 13 by the flanged rollers 15. In conjunction with
10 the distance measurement by the odometer 21, the correction measurement
11 values, which are formed by determining the difference between desired and
12 actual values, are stored with reference to the particular location.

13

14 FIG. 4 shows the situation at the end of the measuring cycle, when the
15 mobile measuring vehicle 1 has reached the stationary measuring vehicle 2 in
16 the course of the surveying operation. By moving the stationary measuring
17 vehicle 2 forward again in the direction of arrow 12, as shown in FIG. 5, the next
18 measuring cycle is initiated.

19

20 While the invention has been illustrated and described as embodied in a
21 method of surveying a track, it is not intended to be limited to the details shown
22 since various modifications and structural changes may be made without
23 departing in any way from the spirit of the present invention.

- 1 What is claimed as new and desired to be protected by Letters Patent is
- 2 set forth in the appended claims:

CLAIMS

What is claimed is:

1. A method of surveying a track, comprising the steps of:

- a) positioning a first and a second measuring vehicle at end points, respectively, of a track section to be measured during a measuring cycle, the first measuring vehicle being designed for mobility independently of the second measuring vehicle which is stationary during the measuring operation;
- b) determining, at the start of each measuring cycle, position coordinates of the stationary, second measuring vehicle, with the aid of a GPS receiver mounted thereon, relative to a fixedly installed GPS reference station located adjacent the track section to be measured, the coordinates of the GPS reference station being known within a terrestrial coordinate system;
- c) setting up a reference line in the form of an optical measuring beam between an emitter mounted on the second measuring vehicle and a receiving unit mounted on the first measuring vehicle;
- d) aligning the reference line with the first measuring vehicle on the basis of the determined position data;
- e) advancing the mobile, first measuring vehicle in the direction towards the stationary, second measuring vehicle to carry out the track surveying operation; and
- f) registering as a correction measurement value any change in position of the receiving unit mounted on the first measuring vehicle relative to the reference line.

2. A method of surveying a track, comprising the steps of:
- positioning a first measuring vehicle at a first end point of a track section to be measured during a measuring cycle;
 - positioning a second measuring vehicle at a second end point of the track section, with the second end point having a known position with respect to a fixed reference point having an absolute coordinate;
 - establishing an optical reference line between the two measuring vehicles;
 - moving the first measuring vehicle in a direction of the second measuring vehicle by a predetermined distance and determining a displacement of the optical reference line perpendicular to a track direction;
 - determining from the displacement of the optical reference line and the predetermined distance an absolute track location; and
 - repeating steps d) and e) until the first measuring vehicle is in close proximity to the second measuring vehicle, thereby surveying the track section between the two end points.

ABSTRACT OF THE DISCLOSURE

In a method of surveying a track (9), a first or mobile measuring vehicle (1) and a second or stationary measuring vehicle (2) are placed at a distance apart from one another on a track section to be measured. A reference line (14) is formed by a laser beam emitted from the stationary measuring vehicle (2). At the start of each measuring cycle, by using a GPS receiver (19), the relative position of the stationary measuring vehicle (2) with reference to a fixedly installed GPS reference station (29) located adjacent to the track section is determined, the said GPS reference station being known within a terrestrial coordinate system. The reference line (14) is aligned with the mobile measuring vehicle (1) on the basis of the determined position data, and the track surveying operation is carried out by advancing the mobile measuring vehicle (1) while changes of the actual track position relative to the reference line (14) are registered.



7.1.2018

Declaration and Power of Attorney for Patent Application

Erklärung für Patentanmeldungen mit Vollmacht

German Language Declaration

Als nachstehend benannter Erfinder erkläre ich hiermit an Eides Statt:

daß mein Wohnsitz, meine Postanschrift, und meine Staatsangehörigkeit den im Nachstehenden nach meinem Namen aufgeführten Angaben entsprechen,

daß ich, nach bestem Wissen, der ursprüngliche, erste und alleinige Erfinder (falls nachstehend nur ein Name angegeben ist) oder ein ursprünglicher, erster und Miterfinder (falls nachstehend mehrere Namen aufgeführt sind) des Gegenstandes bin, für den dieser Antrag gestellt wird und für den ein Patent beantragt wird für die Erfindung mit dem Titel:

METHOD OF SURVEYING A TRACK

deren Beschreibung
(zutreffendes ankreuzen)

- ☒ hier beigefügt ist.
☐ wurde angemeldet am _____
unter der U.S.-Anmeldungs Nr. oder unter der Internationalen Anmeldenummer im Rahmen des Vertrags über die Zusammenarbeit auf dem Gebiet des Patentwesens (PCT)
_____ und am _____
_____ abgeändert (falls zutreffend).

Ich bestätige hiermit, daß ich den Inhalt der obigen Patentanmeldung einschliesslich der Ansprüche durchgesehen und verstanden habe, die eventuell durch einen Zusatzantrag, wie oben erwähnt, abgeändert wurde.

Ich erkenne meine Pflicht zur Offenbarung irgendwelcher Informationen an, die für die Prüfung der vorliegenden Anmeldung in Einklang mit Titel 37, Code of Federal Regulations, §1.56 von Belang sind.

Ich beanspruche hiermit ausländische Prioritätsvorteile gemäss Titel 35, US-Code, §119(a)-(d), bzw. §365(b) aller unten angegebenen Auslandsanmeldungen für ein Patent oder Erfinderurkunden, oder §365(a) aller PCT internationalen Anmeldungen, welche wenigstens ein Land ausser den Vereinigten Staaten von Amerika benennen, und habe nachstehend durch ankreuzen sämtliche Auslandsanmeldungen für Patente oder Erfinderurkunden oder PCT internationale Anmeldungen angegeben, deren Anmeldetag dem der Anmeldung, für welche Priorität beansprucht wird, vorangeht.

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

METHOD OF SURVEYING A TRACK

the specification of which
(check one)

- ☒ is attached hereto
☐ was filed on _____
as United States Application Number or PCT International Application Number
_____, and was amended on _____
(if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, §119(a)-(d) or §365(b) of any foreign application(s) for patent or inventor's certificate, or §365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Applications
(Frühere ausländische Anmeldungen)

Priority Claimed?
Priorität beansprucht?

A 204/99 Austria 12/February/1999
(Number) (Country) (Day/Month/Year Filed)
(Nummer) (Land) (Tag/Monat/Jahr eingereicht)

☒ ☐
Yes No
Ja Nein

(Number) (Country)
(Nummer) (Land)

(Day/Month/Year Filed)
(Tag/Monat/Jahr eingereicht)

☐ ☐
Yes No
Ja Nein

Ich beanspruche hiermit gemäss Titel 35, US-Code, §119(e), den Vorzug aller unten aufgeführten US-Hilfsanmeldungen

I hereby claim the benefit under Title 35, United States Code, §119(e) of any United States provisional application(s) below

(Application No. / Anmeldenr.)

(Filing Date / Anmeldedatum)

(Application No. / Anmeldenr.)

(Filing Date / Anmeldedatum)

Ich beanspruche hiermit gemäss Titel 35, US-Code, §120, den Vorzug aller unten aufgeführten US-Patentanmeldungen bzw. §365(c) aller PCT internationalen Anmeldungen, welche die Vereinigten Staaten von Amerika benennen, und erkenne, insofern der Gegenstand eines jeden früheren Anspruchs dieser Patentanmeldung, bzw. PCT internationalen Anmeldung in einer gemäß dem ersten Absatz von Titel 35, US-Code §112 vorgeschriebenen Art und Weise offenbart wurde, meine Pflicht zur Offenbarung jeglicher Informationen an, die zur Prüfung der Patentfähigkeit in Einklang mit Titel 37, Code of Federal Regulations, §1.56 von Belang sind und im Zeitraum zwischen dem Anmeldedatum der früheren Patentanmeldung und dem nationalen oder im Rahmen des Vertrags über die Zusammenarbeit auf dem Gebiet des Patentwesens (PCT) gültigen internationalen Anmeldedatum bekannt geworden sind.

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s), or §365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.

(Appl. No.)
(Anmeldenr.)

(Filing Date)
(Anmeldedatum)

(Status)
(patentiert, anhängig
aufgegeben)

(Status)
(patented, pending
abandoned)

(Appl. No.)
(Anmeldenr.)

(Filing Date)
(Anmeldedatum)

(Status)
(patentiert, anhängig
aufgegeben)

(Status)
(patented, pending
abandoned)

Ich erkläre hiermit, daß alle von mir in der vorliegenden Erklärung gemachten Angaben nach meinem besten Wissen und Gewissen der vollen Wahrheit entsprechen, und daß ich diese eidesstattliche Erklärung in Kenntnis dessen abgebe, daß wissentlich und vorsätzlich falsche Angaben gemäss §. 1001, Titel 18 US-Code strafbar sind und mit Geldstrafe und/oder Gefängnis bestraft werden können, und daß derartig wissentlich und vorsätzlich falsche Angaben die Rechtswirksamkeit der vorliegenden Patentanmeldung oder eines darauf erteilten Patentbesitz gefährden können.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under §1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

VERTRETUNGSVOLLMACHT: Als benannter Erfinder beauftrage ich hiermit den nachstehend benannten Patentanwalt (oder die nachstehend benannten Patentanwälte) und/oder Vertreter mit der Verfolgung der vorliegenden Patentanmeldung sowie mit der Abwicklung aller damit verbundenen Geschäfte vor dem US-Patent-und Warenzeichenamt:

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith:

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